1.1 Apparatus

1.1.1 Laboratory

For this experiment, a temporary enclosure was assembled inside a larger laboratory to provide a controlled environment in which to set up the fixed-base driving simulator. Figure 1 shows a drawing of the simulator enclosure with the relative dimensions and layout of the vehicle and equipment inside.

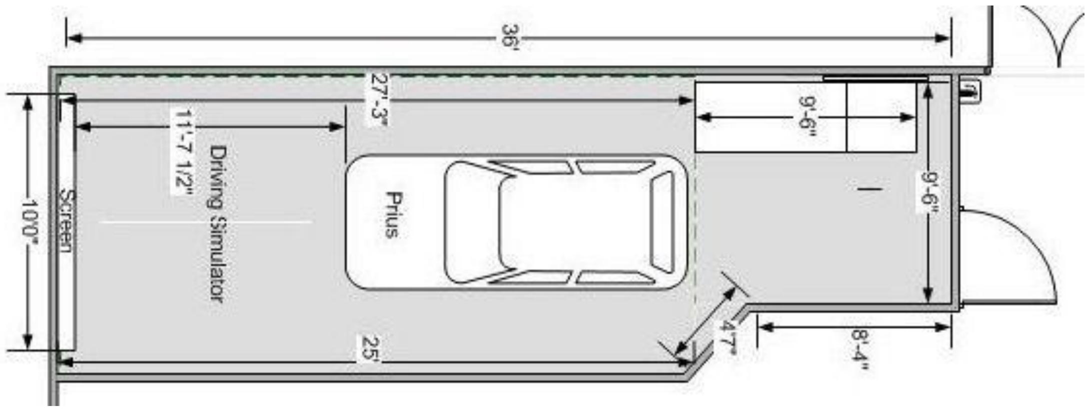

Figure 1. Dimensions and Basic Layout of Simulator Environment

The enclosure's structure consisted of materials from two portable canopies made of interlocking aluminum poles with white tarps for covering the roof and sides. While the canopy tarps provided basic simulator cover, additional materials were added to the roof and walls to permit better experimental control of both light and sound. The wall panels can be seen in Figure 2.

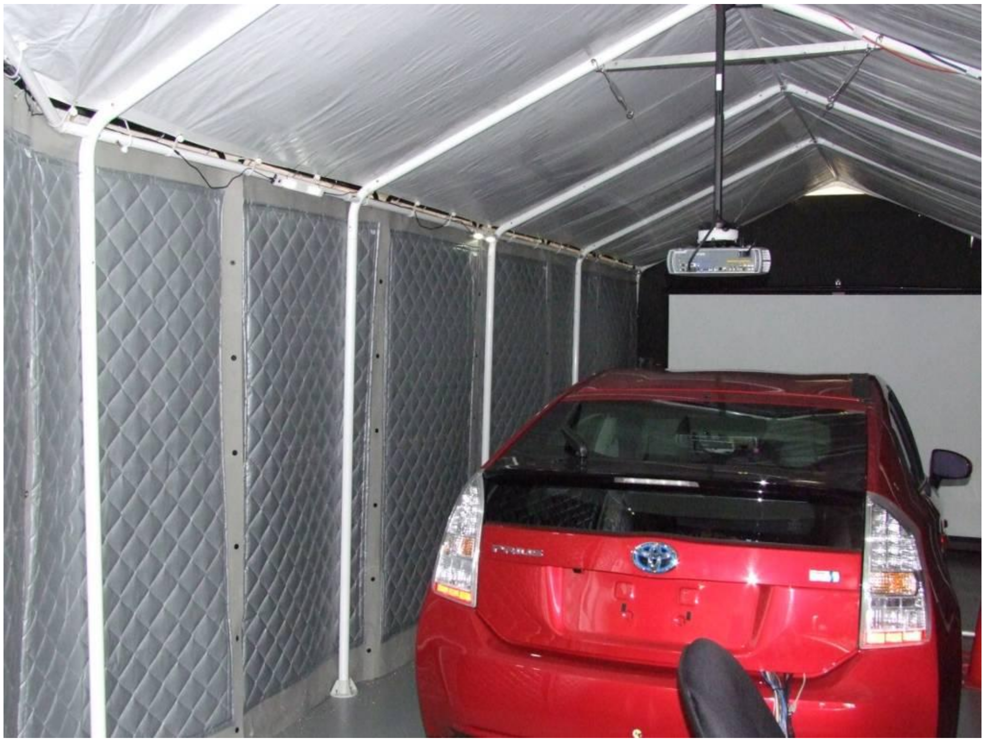

Figure 2. Simulator Enclosure, Roof and Wall Construction Materials

The wall panels were free-standing modular acoustical screens with a noise reduction coefficient of 0.75. These acoustical screens were each 4 feet wide by 8 feet tall. Each screen had a black tubular steel frame that was attached to the canopy frame and the frames of other screens to form the desired light and sound barrier for the simulator walls. Acoustic foam was then placed on top of the roof of the canopy, supported by the canopy frame and white tarps. Thus, the canopy's frame supported both the acoustic foam panels above the roof tarp and the acoustic screens used for the walls.

Once the structure was complete, accent lighting was added to the junction of the wall and ceiling to provide a lighted path to the driver's side of the vehicle. As seen in Figure 1, a door was placed at the end of the structure behind the vehicle. This door was made of one of the acoustical screens and frame, in which a hinge was fabricated to attach the door to the canopy frame. A wheel was mounted under the door frame to allow it to open and close easily.

1.1.2 Driving Simulator

Inside the simulator enclosure, components of the fixed-base simulator included a production test vehicle (2010 Toyota Prius), an Intel Pentium 4 computer, a ceiling-mounted digital projector (1024 x 768) positioned above the vehicle, and a forward projection screen (10 ft x 10 ft). The STISIM drive simulator software was used.

The roadway scene consisted of a 4-lane rural highway with two (12 foot wide) lanes in each direction, separated by double yellow lines. After an initial curve, all secondary tasks were performed on straight-road sections. There were no cross roads and lighting was selected to simulate daytime driving conditions. Single oncoming vehicles were programmed to appear approximately every 1300-1600 feet (i.e., once every 15-20 seconds), with varying speeds and lateral positions in the nearest oncoming lane. Scenario, roadway, and vehicle parameters are described in Appendix I.

A touch screen was installed inside the vehicle and was connected to a separate computer, which was used to generate visual stimuli for secondary tasks (see Figure 3). The simulator computer, secondary task computer and other experimenter materials were located at a control station located behind the vehicle on the passenger side. From there, two experimenters could operate all the equipment and communicate with a participant using a speaker and microphone system.

Figure 3. Prius Interior and Touch Screen

Sensors that recorded steering, accelerator and brake inputs were attached temporarily to the test vehicle. Specifically, a bracket (see Figure 4) was developed to couple either front tire of the test vehicle to a turn plate on the ground while the vehicle tires were off the ground (vehicle supported by 5 jack stands). The bracket and turn plate assembly mounted to the front tire provided steering inputs to the driving simulator when the participant moved the steering wheel, allowing the simulator to run without the vehicle being turned on.

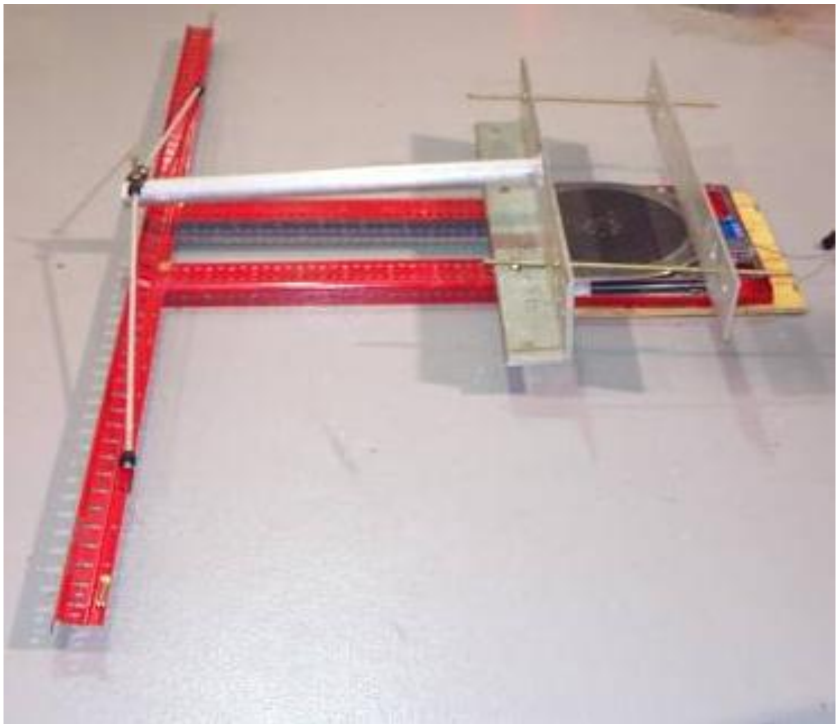

Figure 4. Apparatus for Recording Steering Wheel Movement

A Seeing Machines FaceLAB eye tracking system was used to record the driver's head pose and gaze. Head pose used three parameters to define position and three parameters to define orientation. FaceLAB output gaze rays for each eye. Each ray had an origin at the center of the respective eye and vectors pointing toward the object being looked at. Gaze was represented as pitch and yaw angles. The pitch and yaw angles were transformed into a direction vector. Dual gaze was converted into a single gaze vector. The system used two stereo cameras mounted on the dashboard and was relatively unobtrusive. To assist the system in tracking facial features, participants applied five latex target stickers to their faces during system calibration.

The vehicle data acquisition system was configured to collect steering wheel position, brake and throttle inputs, and participant responses to the target detection task. That system also collected video data from multiple camera locations, in addition to collecting timing data from the various systems (STISIM, FaceLAB, and the secondary task computer) to provide time syncing of all the data in post processing routines. In addition, the STISIM simulation computer collected data for its respective performance measures. The primary data channels are displayed in Table 1.

Table 1. Data Collection Channels

Data Channel	Description	Units	Resolution
Vehicle Speed	STISIM	km/h	1 km/h
Range	Distance to the lead vehicle, STISIM	m	.5 m
Range-Rate	Relative velocity between the vehicles, STISIM	m/s	.1 m/s
Lateral Position	Lateral position in reference to the simulated lanes, STISIM	cm	2 cm
Hand Wheel Position	Angular position of the steering wheel (0 degrees = straight)	deg	.1 deg
UTC Time	Time of day	HH:MM:SS	1 s
Event Task	DT button press response	0 or 1	1/30th s